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Segmentation of aortic flow in real-time spiral phase-contrast MRI for assessment of stroke volume variability

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Introduction

- Real-time spiral phase-contrast MRI is capable of non-invasively measuring the stroke volume associated with each individual heartbeat.
- The quality of these measurements depends on how good the segmentation of aortic flow is.
- Segmentation process is hampered by the low-resolution and low-contrast nature of real-time images.
- **Goal**: to propose a robust segmentation algorithm, capable of isolating aortic flow from neighboring flows.

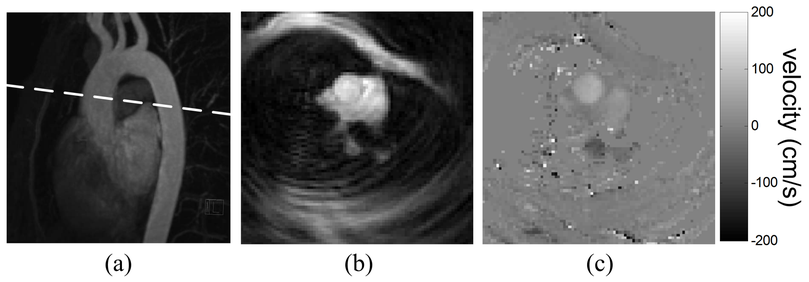

Figure 1: (a) Slice prescription at the ascending aorta; (b) morphological image; and (c) velocity map.

Model-based segmentation

- Contours of the aorta are imposed onto a Gaussian: (unsharp mask+offset)×Gaussian.
- The offset value controls the contours of the binary mask (Fig. 2).
- Aortic centroid estimation is needed.

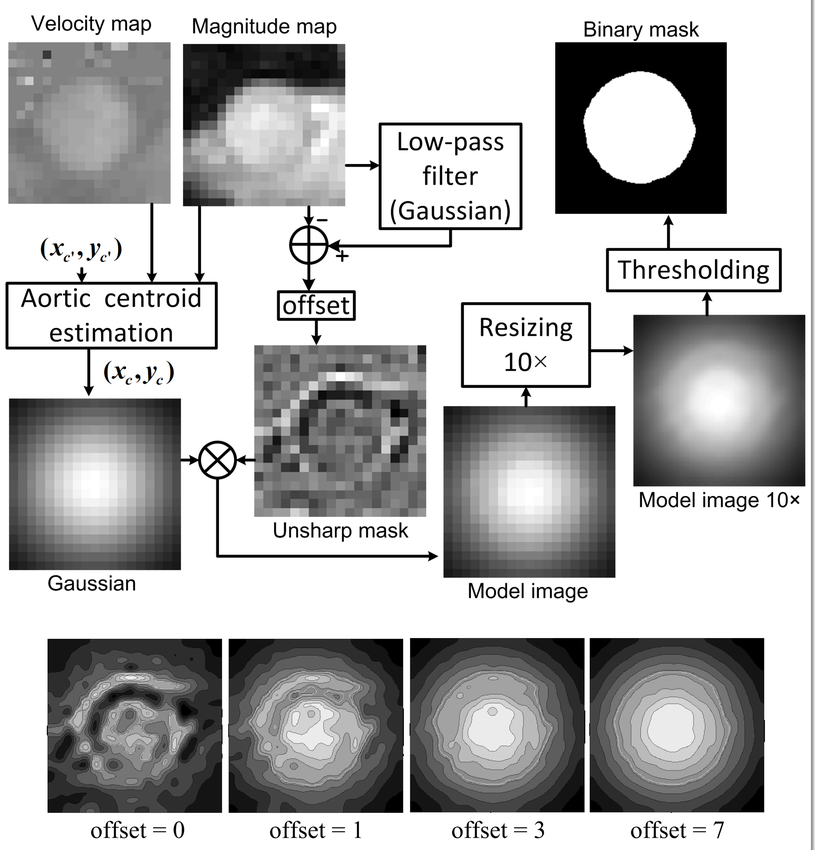

Figure 2: Diagram of the proposed segmentation method (top), and effect of the offset value (bottom).

Centroid-tracking algorithm

- An iterative process based on template matching.
- Combination of two binarized images: basic shape and contours.
- Templates repositioned to the barycenter.
- Process ends at a point of high equilibrium and high correlation.

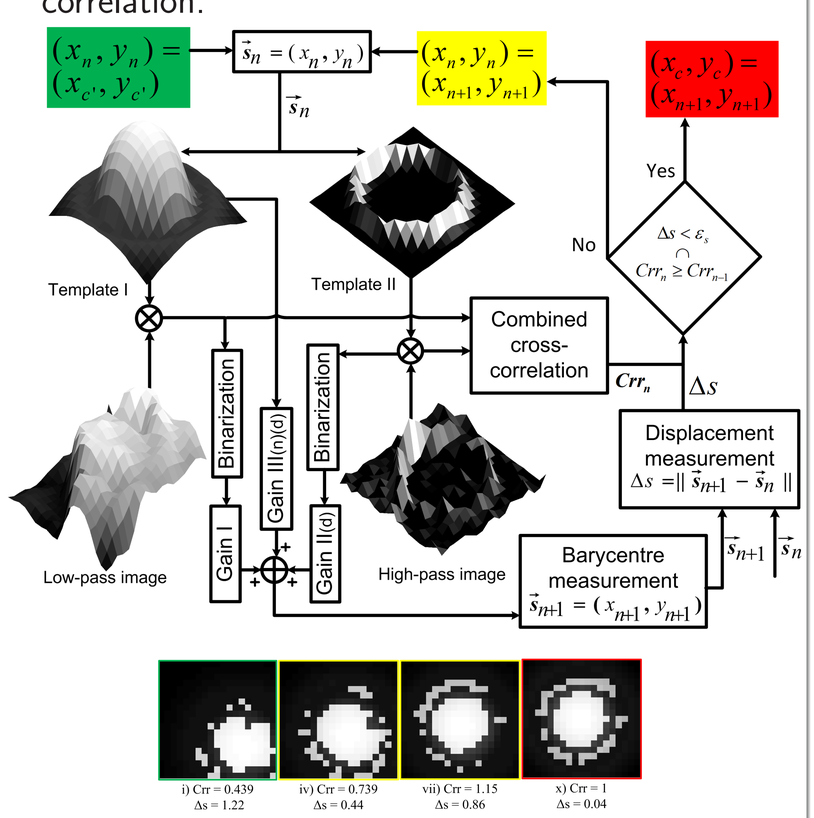

Figure 3: Centroid-tracking algorithm (top), and a couple of iterations, from an abitrary point to the estimated centroid (bottom).

Results and discussion

- Different datasets have different levels of quality.
- Results can be classified by image quality.

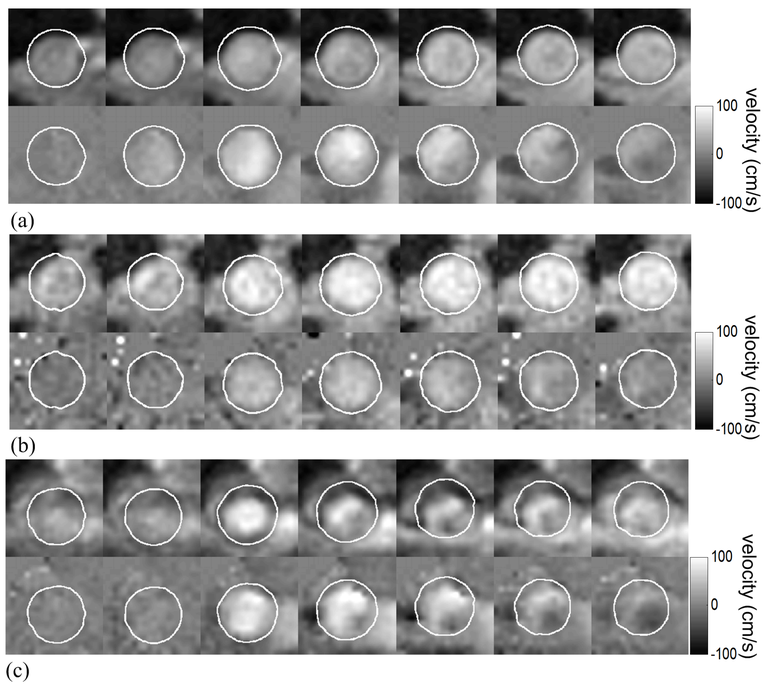

Figure 4: Segmentation results (during systole) for three different subjects: (a) good image quality; (b) medium image quality; and (c) low image quality.

Results and discussion

- Flow associated to each frame is calculated (Fig. 5).
- Integration of flow during each heartbeat provides the stroke volume variability curve (Fig. 5d).

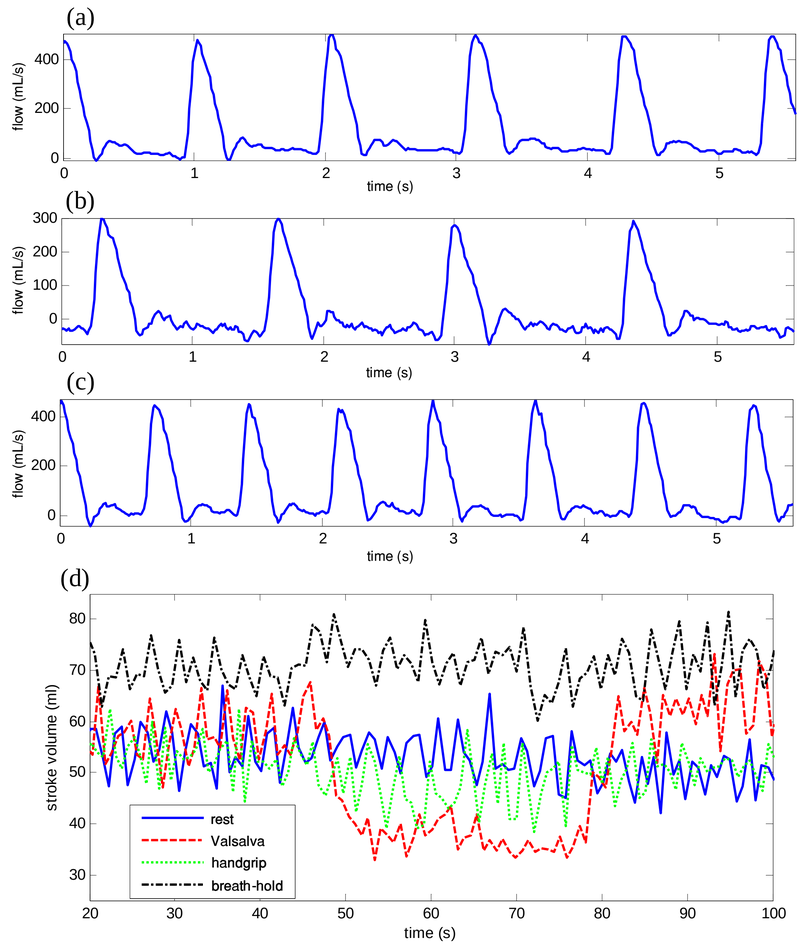

Figure 5: Flow curves for (a) a good-quality dataset, (b) a medium-quality dataset, and (c) a low-quality dataset; and (d) stroke volume variability curves for one subject under different stimuli.

- Overestimation is tolerable, as long as neighboring flows are excluded.
- Assuming a parabolic profile, a 10% underestimation of the aortic radius or a 10% error in aortic centroid estimation would result in only 3.6% error in flow estimation.
- Average centroid displacement between frames is only 1% of the radius.

Conclusion

- We presented a robust model-based approach for segmenting aortic flow in real-time spiral PC-MRI images.
- This takes real-time MRI one step further towards becoming the non-invasive gold standard for assessment of stroke volume variability.

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